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HYDROGEOCHEMICAL INVESTIGATIONS IN THE VICINITY OF THE FORMER HAVELOCK ASBESTOS MINE NEAR BULEMBU, ESWATINI (FORMERLY SWAZILAND)

Christian **WOLKERSDORFER**, MASSAF – TUT
Kagiso Samuel **MORE**
Elke **MUGOVA**
Nokuthula **NCHABELENG**
Anna Johanna **SOTIRALIS**

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WHAT I WILL TALK ABOUT

- Location of the mine
- Historical data
- Asbestos problem
- Investigations
- The results
- Conclusions

LOCATION OF THE MINE – KINGDOM OF ESWATINI

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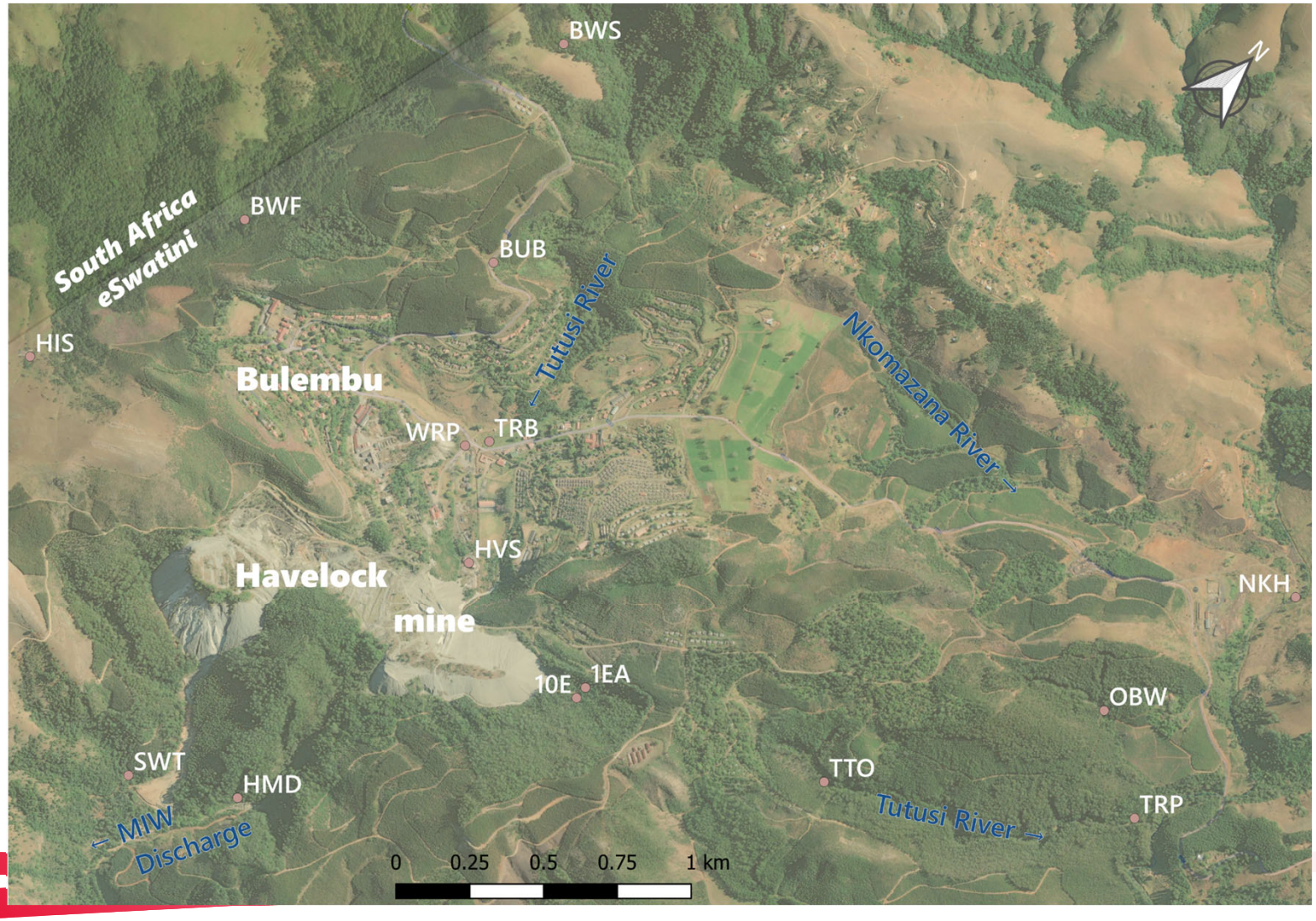
LOCATION OF THE MINE – HYDROGEOLOGICAL BASELINE STUDY



ASBESTOS PROBLEM

- Asbestos: Group of minerals
  - chrysotile, amosite, crocidolite
- Recognised as health hazard
  - OSHA (Occupational Safety and Health Administration)
  - EPA (Environmental Protection Agency)
- Lung cancer
- Mesothelioma – Soft tissue tumour
- Scarring of the lungs – asbestosis
  - Reduced lung capacity and eventually death

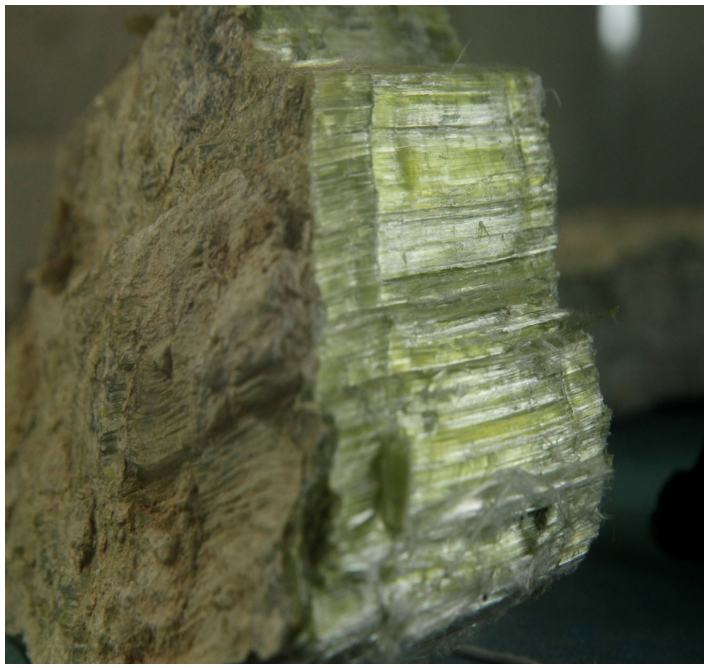
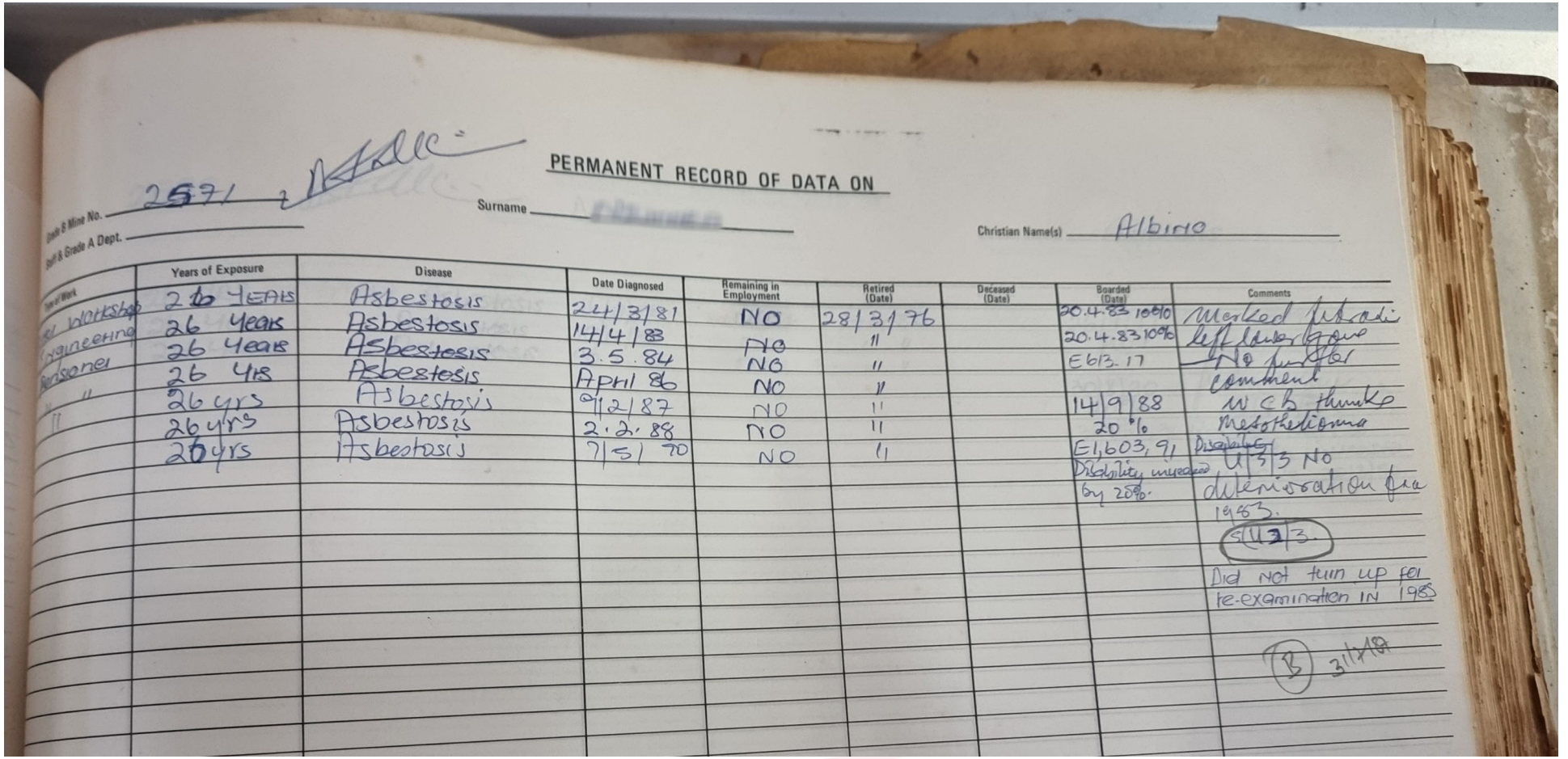


Image: Wolkersdorfer (Bulembu mining museum, 155 level)

ASBESTOS PROBLEM



PERMANENT RECORD OF DATA ON

Surname [redacted]

Christian Name(s) Albino

Mine & Mine No. 2571

Staff & Grade A Dept.

Nature of Work	Years of Exposure	Disease	Date Diagnosed	Remaining in Employment	Retired (Date)	Deceased (Date)	Boarded (Date)	Comments
Workshop	2 to 4 YEARS	Asbestosis	24/3/81	NO	28/3/76		20.4.83 10%	Marked tuberculosis left lower lobe
Engineering	26 years	Asbestosis	14/4/88	NO	"		20.4.83 10%	No further comment
Surfaceman	26 years	Asbestosis	3.5.84	NO	"		E613.17	WCB thinks Mesothelioma
"	26 yrs	Asbestosis	April 86	NO	"			
"	26 yrs	Asbestosis	9/2/87	NO	"		14/9/88 20%	Disability 17/3/3 NO
"	26 yrs	Asbestosis	2.2.88	NO	"		E1,603,91 Disability increased by 20%	determination fee 1953.
	26 yrs	Asbestosis	7/5/90	NO	"			5/11/3.
								Did not turn up for re-examination IN 1985
								31/1/19

Image: Wolkersdorfer (Bulembu mining museum)

HAVELOCK ASBESTOS MINE

- in the north-western part of eSwatini, about 20 km south-south-east of Barberton (South Africa)
- 4 km south of eSwatini's highest peak, Emlembe (1862 m)
- Quartzite, granite, biotite-muscovite schist, **serpentinite**
- Open pit and underground area: 1.5 × 0.4 km
- Overburden and tailings: 50 ha
- Chrysotile mining began in 1939 and ended in 2000
- British company Turner and Newall until around 1980
- Asbestos production between 1939 and 2000: 1.8 million t
- One of the five largest asbestos mines in the world at the time

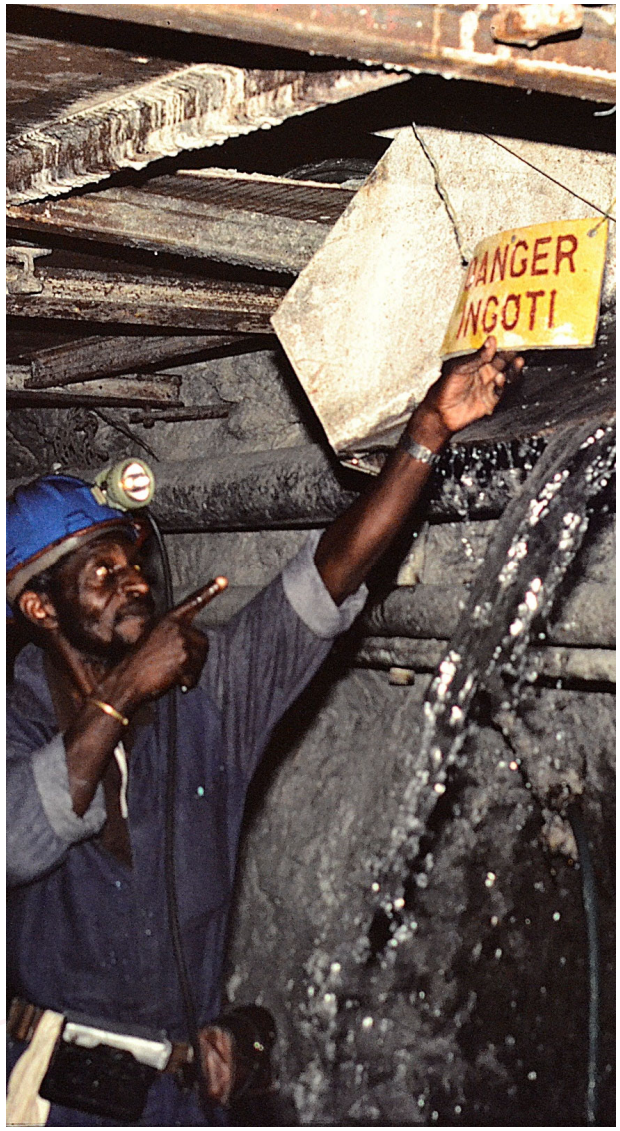


Image: Bulembu mining museum, Havelock mine

HAVELOCK ASBESTOS MINE

Image: Bulembu mining museum, Havelock mine

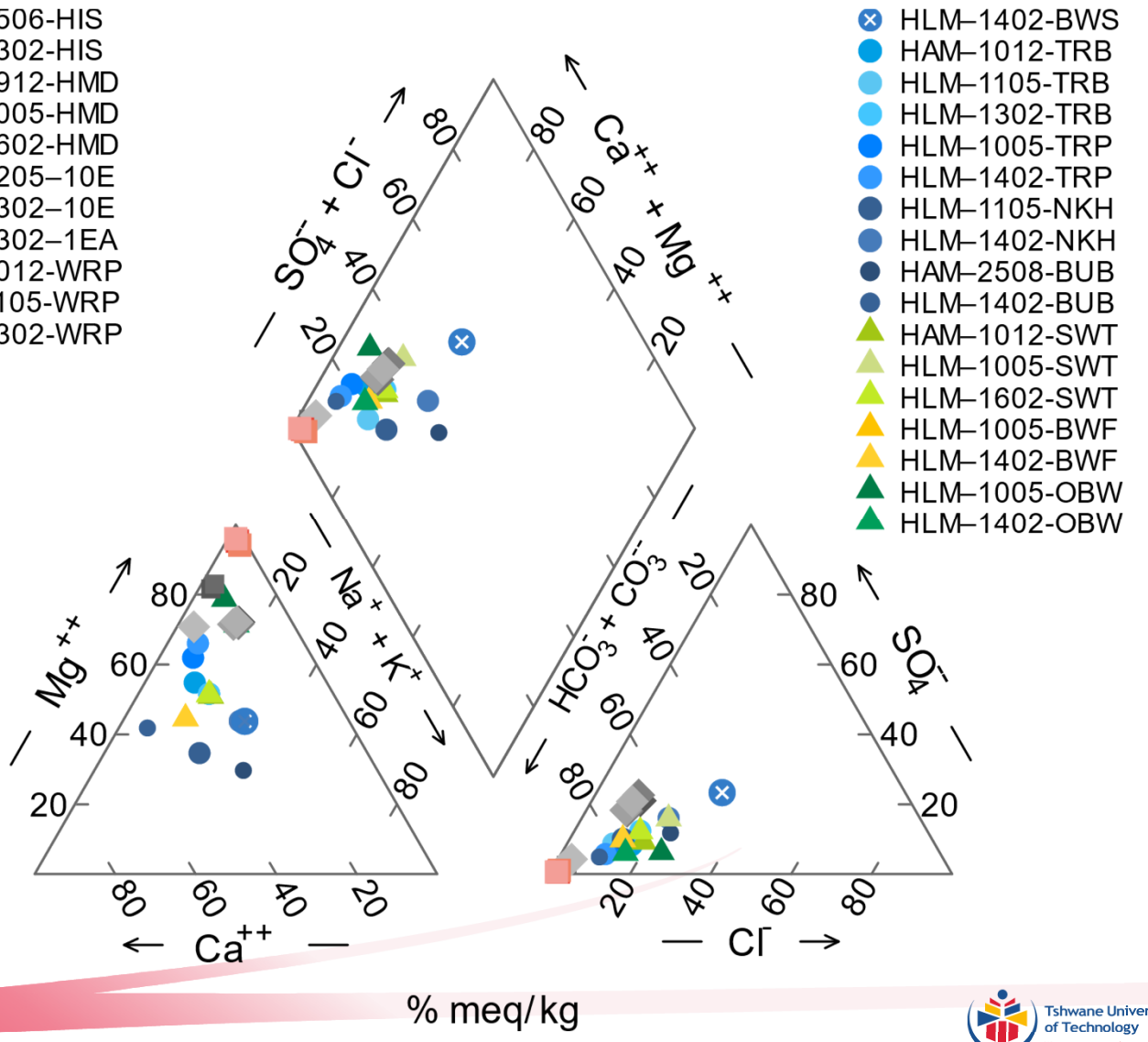
INVESITIGATIONS

- 4 sampling campaigns
- 27 water samples
  - Main elements (unfiltered)
  - Trace elements (filtered 0.45 µm, acidified)
  - On-site parameters
  - Isotopes
- 20 flow measurements
- 3 tracer tests (NaCl, Uranine, Eosine Y)
- Microscopy of filtered mine water
- Shaft measurements – pH, electrical conductivity, temperature

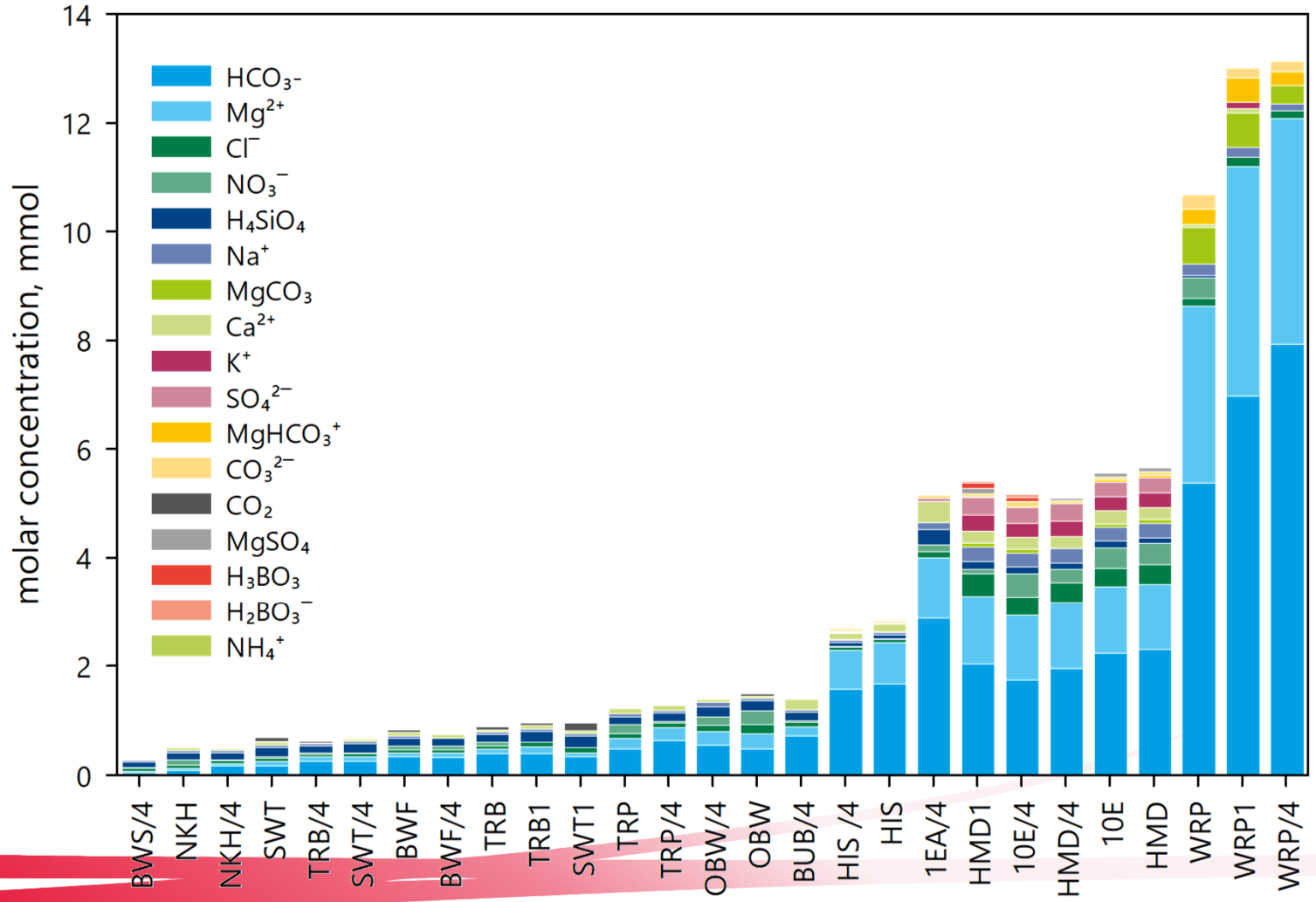
Results – Hydrogeochemistry

Parameter	Min	Max	Average
Temperature, °C	14,4	25,0	**19,4**
Electrical conductivity, µS/cm	25	670	**192**
pH, –	6,7	9,0	**8**
Redox, mV (SHE corrected)	360	480	**430**
O_2-Saturation, %	41	101	**84**
TDS/EC, (mg × cm/µS)	0,48	1,34	**0,85**
Ca, mg/L	2	11	**5**
Na, mg/L	1	6	**3**
Mg, mg/L	1	116	**25**
K, mg/L	<0,5	12	**3**
SO_4, mg/L	<2	35	**8**
Cl, mg/L	2	15	**5**
NO_3, mg/L	<0,1	5,3	**2**
HCO_3, mg/L	10	504	**118**

RESULTS


HLM–2506-HIS
HLM–1302-HIS
HAM–0912-HMD
HLM–1005-HMD
HLM–1602-HMD
HLM–1205–10E
HLM–1302–10E
HLM–1302–1EA
HAM–1012-WRP
HLM–1105-WRP
HLM–1302-WRP
HLM–1402-BWS
HAM–1012-TRB
HLM–1105-TRB
HLM–1302-TRB
HLM–1005-TRP
HLM–1402-TRP
HLM–1105-NKH
HLM–1402-NKH
HAM–2508-BUB
HLM–1402-BUB
HAM–1012-SWT
HLM–1005-SWT
HLM–1602-SWT
HLM–1005-BWF
HLM–1402-BWF
HLM–1005-OBW
HLM–1402-OBW
$SO_4^{--} + Cl^-$
$Ca^{++} + Mg^{++}$
Mg^{++}
$Na^+ + K^+$
$HCO_3^- + CO_3^{--}$
SO_4^{--}
Ca^{++}
Cl^-
% meq/kg

Results – PHREEQC-based Species Distribution



RESULTS – "APPELO"-DIAGRAMME

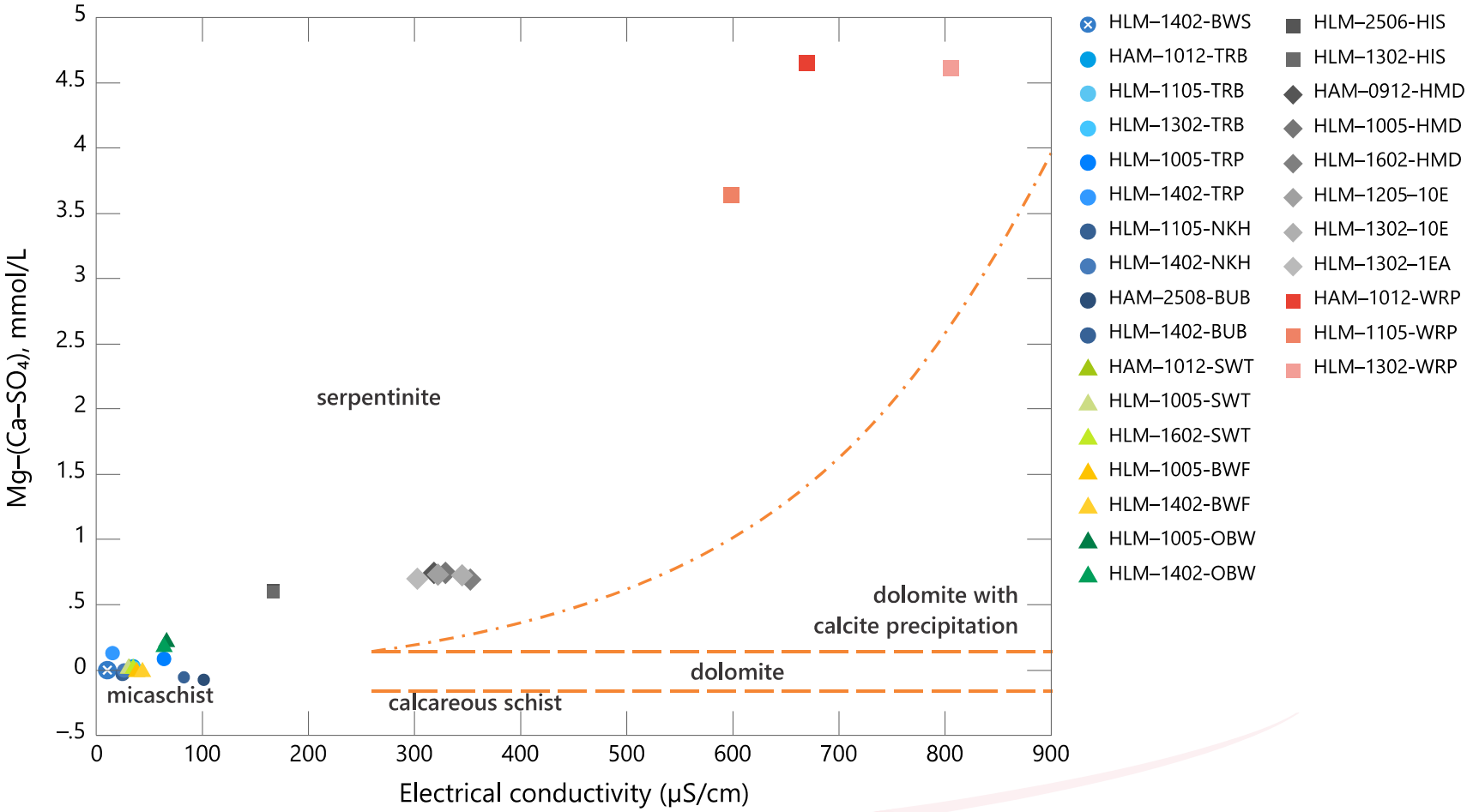
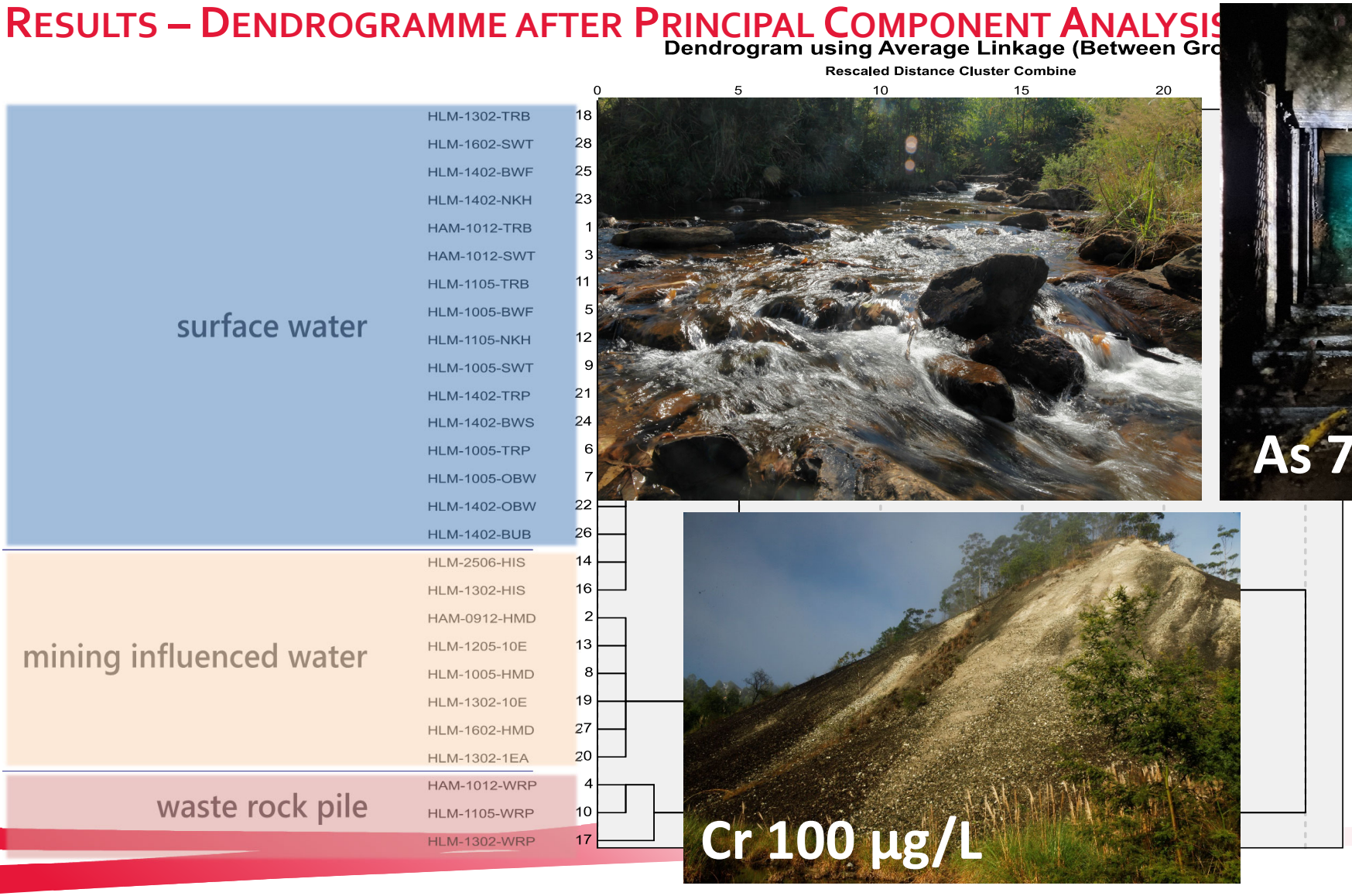


diagram layout type based on Appelo et al. (1983)

RESULTS – DENDROGRAMME AFTER PRINCIPAL COMPONENT ANALYSIS



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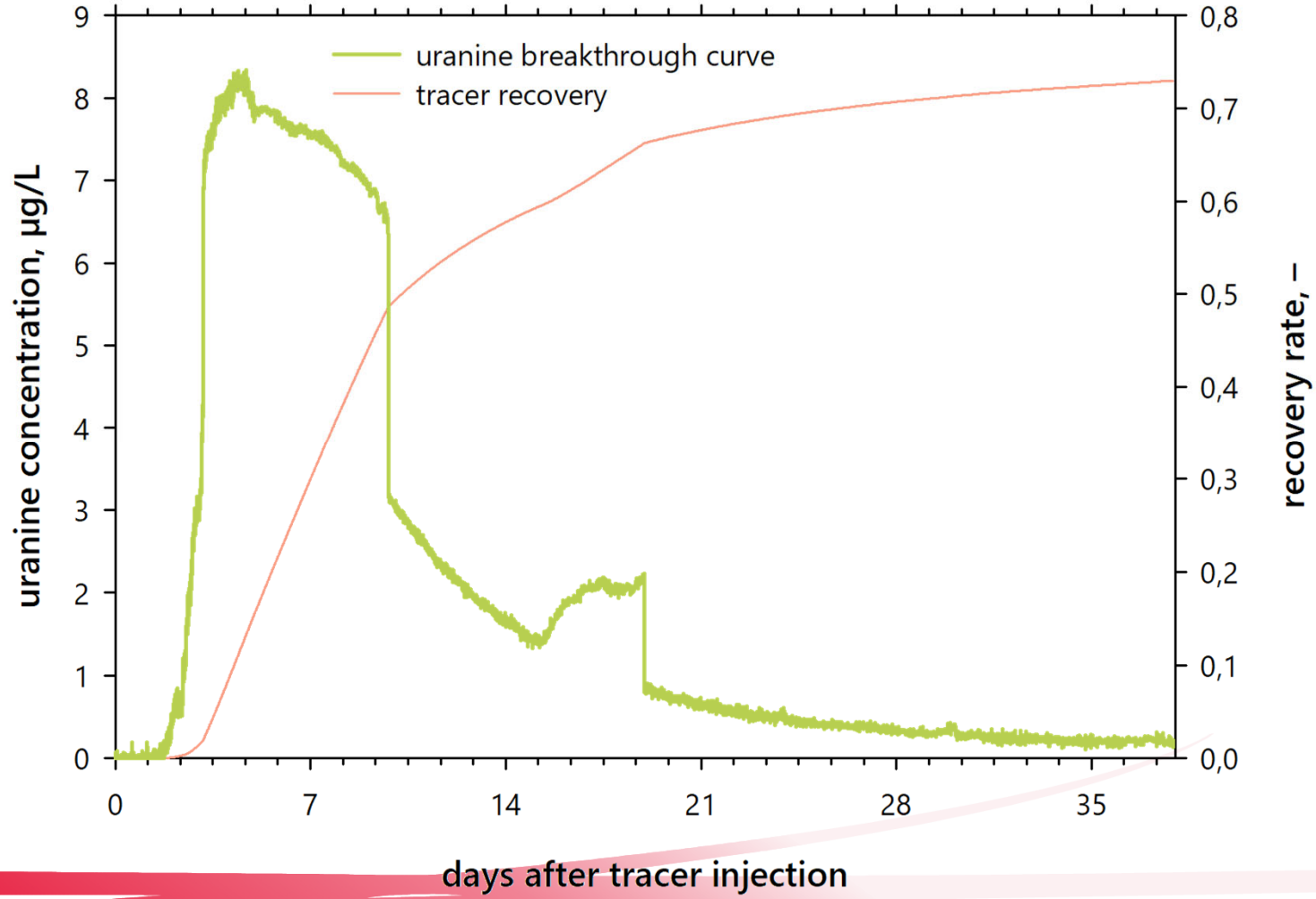
TRACER TEST RESULTS

TRACER TEST RESULTS



CONCLUSIONS

- Water quality in the mine and surrounding area is drinking water quality according to WHO
- Only "Problem Elements"
  - As in the mining influenced water (3300 L/min – 120 kg per year)
  - Cr in the spoil heap (1 L/min – 50 g per year)
- Good hydraulic connection between main shaft and outlet
- "A few" asbestos fibres in the mine water

- Any change causes deterioration of the situation

- South African-eSwatini consortium wants to mine the asbestos tailings, extract magnesium and "rehabilitate" the dumps – allegedly

GLÜCKAUF – AND THANK YOU VERY MUCH FOR LISTENING!

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Contact

WWW.WOLKERSDORFER.INFO

CHRISTIAN@WOLKERSDORFER.INFO